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OVERVIEW OF SYSTEMIC RISK APPLIED IN THE CASE OF PORTUGAL

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Overview of Systemic Risk applied in the case of Portugal

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Abstract

The aim of this dissertation is to explain the implications of systemic risk in the case of Portugal, specifically, the impact of a financial institution`s bankruptcy in the portuguese economy. Despite systemic risk exists before the global financial crisis, the extent of its negative effects during the recent crisis abruptly raised the interest of researchers. In the recent decades significant concerns about the stability of national and international financial systems have been raised. These concerns have been underlined by the current world financial crisis. With this work, I intend to highlight the effects of systemic risk in the different economic sectors. For this, autoregressive distributed lag regression methods were used. The results show a positive relationship between banks´ stock prices and non-financial companies stock prices meaning that the failure of a financial institution is likely to have serious repercussions in the financial system as a whole. In this dissertation, systemic risk is set as the main rationale to understand financial crisis, prudential supervision and as a key driver for crisis management.

Keywords: Systemic risk, financial crisis, banking sector.

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1 Introduction

Although systemic risk has been present before the burst of the recent global financial crisis, the extent of its negative effects raised the interest of many researchers in its origins and trying to find ways to mitigate it.

Despite the diversity of studies in this theme, this work focuses on exploring the impact of systemic risk in the case of Portugal in the context of the recent financial crisis which began in 2007.

The subject of the study includes possible forms of quantification and measurement of the effect of a bank failure in the rest of the market system.

There is no point in talking about risk unless we mention returns. Returns are the prospective financial rewards relative to an investment. Furthermore, risk is the potential for unexpected fluctuations in returns, hence generating losses. Meaning that, investors should demand higher expected returns from riskier investments. In addition, a systemic problem is a phenomenon which is experienced by the whole group or system, such as economy, market or society and not just particular parts of it.

Systemic risk is arguably the most important issue financial systems face today. Even though systemic risk events have been taking place for centuries, the financial industry and regulatory bodies have been focusing on these matters only since the Credit Crisis from 2007. Currency crises represent one of the oldest categories of systemic risk which dates to 1200s (Gottesman (12)). Therefore, systemic risk analysis is still in an early stage and there is as yet no single, universally accepted definition for this kind of risk. I present below some definitions which have been publicly communicated in recent years by well-known academics who focused on this theme: "Systemic risks are developments that threaten the stability of the financial system as a whole and consequently the broader economy, not just that of one or two institutions." (Bernanke (5)); "A risk of disruption to financial services that (i) is caused by an impairment of all or parts of the financial system and (ii) has the potential to have serious negative consequences to the real economy. Fundamental to the definition is the notion of negative externalities from a disruption or failure in a financial institution, market or instrument." (IMF, BIS, FSB 2009, p. 6).

Actually, these definitions have one common feature. They depict systemic risk caused by underlying risks to have the potential to severely impact the financial system as well as the real economy. This can be explained by the fact that large financial companies are closely interconnected and interdependent, meaning that the failure of one company can set off a chain reaction that jeopardizes the entire financial system, as happened in 2008. Note therefore, that according to De Bandt and Hartmann (7), systemic risk can be distinguished horizontally or vertically. The horizontal approach is limited to events in the financial system. In contrast, the vertical view focuses on systemic risk, which affects not only the financial system but also the real economy.

In order to analyze systemic risk, we should understand another important concept, which is the contagion effect. Contagion, often synonymous with domino effect, can be defined as the probability that the instability of an institution will spread to other institutions, causing a system-wide crisis. The higher or lower interconnection between those institutions determines the transmission of shocks through different channels that causes the contagion effect. Some examples of contagion are the increased uncertainty in the financial system as well as an unsustainable increase in housing prices, causing a real estate market bubble. The banking sector is particularly sensitive to contagion (Swaga (32)). Given this, contagion is a mechanism of systemic risk through which it materializes and spreads in or outside the financial system.

Systemic risk analysis has not yet evolved into a standard component of risk management as it comprises many different definitions, sources and impacts, as it develops quickly and can be unpredictable, making it a very complex and broad topic. Due to these challenges and considering the devastating impact of systemic events it is crucial to understand such risks and monitor them in order to protect the stability of financial markets. Multiple new regulatory bodies have been working hard in overseeing and enforcing new rules. Most of those rules are aimed at the banking sector, as it was widely affected. Taking all in consideration, financial institutions have demonstrated a commitment in better understanding, quantifying, monitoring and mitigating systemic risk.

This thesis is organized in five sections. In Section two we considered the theoretical framework where we define systemic risk, we give an overview of the financial situation in Portugal and Europe over the times and we mention also the main events which originated the financial crisis started in America. In Section three we present the literature review and we detail the main economic theories that attempt to explain systemic risk phenomenon. In Section four we characterize the data; we introduce and analyze the models and we explain the model used in the estimations (autoregressive descriptive lag model). Finally, in Section five we present the work conclusions.

2 Theoretical Framework

2.1 Portugal and the Crisis

According to the "Annual Report – The Portuguese Economy" (2014) from Banco de Portugal, the Portuguese financial crisis was preceded by a long period of strong economic growth together with credit expansion, like what happened with previous financial crisis. To understand the evolution of the economy and the origins of the financial crisis in Portugal we should consider two main factors. The first one is that the Portuguese economy is characterized by persistent structural weaknesses, namely, it has one of the lowest rates of education in EEC (European Economic Community), a peripheral geographical position in relation to the main European markets, and a productive structure based in low-value-added industries, which translates in low levels of productivity and consequently low economic growth, reflecting the lack of competitiveness. On the other hand, the European integration process, in the late 1990s, led to many transformations and significant shocks. Among this major changes, stand out, in first place, the financial sector deregulation and the liberalization of the international capital movements; secondly, the accession to the European Monetary System and the decision to adopt the Euro; and thirdly, the privatization of big public companies (in a first moment, banks and insurance companies; in a second moment, energy sector, telecommunication and transport companies), partly driven by the need to reduce public debt in order to fulfil the euro zone membership criteria. As a result of some of these measures, real interest rates decreased significantly. These developments were followed by a rapid catch-up of the Portuguese economy to the levels of EU average in the second half of the 1990s. However, they are closely related with the main economic weaknesses of the Portuguese economy at the present time. In fact, the sharp fall of the real interest rates combined with the massive inflows of foreign capital created inflationary pressures, on account of increased private and public demand, which affected the competitiveness of the traditional sectors of the Portuguese industry. In addition, it fostered the rising indebtedness of the various institutional sectors (corporations, households and the government). Moreover, the end of the nominal depreciation of escudo, due to the importance of exchange rate stability, has worsened this situation as it resulted in the reduction of Portuguese exports.

In contrast to what happened in the second half of the 1990s, a long period of mediocre growth verified from the turn of the millennium. This situation has been accompanied by the beginning of the Subprime Crisis, causing a financially unsustainable indebtedness.

Consequently, Portugal agreed to an economic adjustment program which required to adopt austerity measures and to implement several structural reforms. The economic adjustment program focused in three main aspects: fiscal consolidation, mainly spending cuts and increasing revenues by adjusting value-added tax rates and raising fees for health care services, for example; financial stability that meant to reduce leverage and to strengthen regulatory supervision; and a structural transformation focused on reforming labor and products market and on improving the business environment, through jobs creation and increasing labor market flexibility.

In the short-term, after the economic adjustment program implementation Portugal experienced a deepened recession, as showed by record unemployment rates and lower nominal wages, causing an increase in net emigration. In addition, there was a deeper than expected economic contraction. Despite that, the economic adjustment program ensured Portugal´s international reputation, crucial to guarantee a continued access to capital markets and to regain credibility.

In parallel to this, as in United States, the Portuguese real estate market was significantly affected.

In order to assess the impact of the crisis in the real estate market it is crucial to understand that home ownership levels are particularly high in Portugal and tend to raise in the future due to the fact that interest rates have been kept low over recent years and that the mortgage market has become increasingly competitive (Housing Conditions in Portugal, Matos 2009).

The period that preceded the crisis was characterized by strong GDP growth explained by the uncontrolled expansion of the construction sector. In fact, the volume of real estate increased significantly in proportion to the demand. This speculative growth was stimulated by easily obtained credit. Banks provided loans and mortgages without control or safety and real estate was a source of investment with the intention to obtain large profits.

However, when other European countries were affected by the banking sector crisis as a result of having “toxic assets” the Portuguese banks were highly impacted and there was a decline in the value of the real estate assets they held.

For this reason and because of the recession resulting from the economic adjustment program, wages and social benefits decreased, families lost purchasing power and showed difficulties in meeting their commitments with bank loans for housing. Some of them got into financial insolvency and lost the dwellings acquired.

As consequence, the number of real estate transactions and mortgages declined.

As if that wasn't enough, the construction sector was also severely impacted. In one hand, because of public spending cuts due to fiscal consolidation requirements, and on the other hand because of the real estate crisis and the difficulty to access to financing. According to “Associação dos Profissionais e Empresas de Mediação Imobiliária de Portugal” (APEMIP), national banks in 2014 were providing 5% of the credit that was granted to the real estate sector prior to the crisis. The number of new dwellings built fell from 114 000 in 2001 to 6785 in 2014 (European Construction Sector Observatory. Country Profile Portugal. March 2018).

2.2 US Subprime Crisis

When the United States Subprime Crisis burst in the summer of 2007, few predicted its effects would be felt so deeply and that it would turn lately into a widespread liquidity crisis of unthinkable proportions.

The financial markets stress levels enhanced significantly in August 2007 when BNP Paribas was forced to halt redemptions on three of its investment funds with large exposures to securitization assets backed by U.S. subprime mortgages, which had become largely illiquid (Skidelsky (31)).

This scenario worsened in March 2008 when Bear Sterns was rescued. Although, this indicator`s major increase was related to the aftermath of the Lehman Brothers Holdings Inc. breakdown on September 15, 2008, at that time the fourth largest U.S. investment bank.

The central cause of Lehman`s demise according to Wiggins, Piontek and Metrick (34) was its dependence on the subprime mortgage market. Prior to 2007, a rising in U.S. housing prices and the prevalence of low interest rates made real estate investments highly attractive. So, as other U.S. investment banks did, Lehman Brothers took advantage of that boom period and extended huge subprime mortgage loans. As a result, excessive borrowing triggered high degrees of leverage. In addition, short-term borrowings were an important source of funds. Indeed, sizable shares of their liabilities were overnight loans that needed to be rolled over each day. However, the unexpected happened and the real estate bubble deflated, so Lehman suffered large losses on real estate assets, which threatened its solvency. Confidence in the firm waned precipitating a liquidity crisis. Market participants started to question firms` solvency and viability, cutting off the firms` short-term funding. Lehman had almost no cash on Friday, September 12, and it was clear the firm would immediately default on obligations if it opened for business on September 15. The scars of this last event continue to remain visible in the global financial system despite the remarkable strives to avoid its impact. The Lehman Brothers bankruptcy caused the collapse of several important financial institutions on both sides of the Atlantic. It marked the tipping point into a global financial crisis making it a source of systemic risk. Policymakers all over the world responded quickly, taking unprecedented actions to prevent the economic and financial crisis getting even worse.

2.3 Madoff's Pyramid

As if it was not enough, a new scandal erupted on the late 2008, "Bernie" Madoff`s Ponzi Scheme. How does a Ponzi scheme work? A Ponzi scheme promises high rates of return with little risk to investors. It relies on a constant flow of new investments to continue to provide "returns" to old investors. In fact, the promoter solicits funds from new investors, but little or no investment occurs. What happens is that the promoter keeps almost all the money and pays "returns" to the older investors. Bernard L. Madoff carried out a 50 billion-dollar Ponzi scheme, keeping it for over 15 years in an economic system which people thought was carefully controlled by regulations and supervised by various institutions.

Madoff was seen as a reliable person. Investors trusted him because of his social status. He was a former non-executive chairman of NASDAQ stock market and founder of Bernard L. Madoff Investment Securities LLC, which was the sixth largest market maker on Wall Street back then. Given that, when Madoff was discovered he discredited even more the investment community, creating a portrait of billions of losses that corresponded to years of savings, which created a lot of uncertainty regarding the performance of the financial regulatory system.

According to Rhee (28), this situation led the SEC (Securities and Exchange Commission) to enhance the financial due diligence by fund managers, institutional investors and other market participants and, that way, assess systemic risk, to increase the transparency of financial market in order to protect future investors.

Taking this into account, we can conclude that big companies have the potential to fail just like small companies if the right structures are not put in place and implemented, contradicting the fact that there are “Too big to fail” companies, and that, actually, this events stimulated the need to implement more robust risk management systems.

2.4 European Sovereign Debt Crisis

According to Kräussl, Lehnert and Stefanova (21), despite the efforts to minimize the effects of the Financial Crisis in the European Union, it eventually brought the European Sovereign Debt Crisis, with the collapse of Iceland`s banking system, which spread to Greece, Ireland and Portugal. The debt crisis led to a crisis of confidence for European businesses and economies. In this period of time, several European countries faced the collapse of financial institutions and most of them had a high level of government debt. Moreover, some European countries were unable to repay their government debt, or to bailout their banks without further external assistance (European Central Bank, International Monetary Fund or, European Financial Stability Facility, created, later on, in 2010). In the case of Greece, it was needed external assistance since May 2010. Greece received several bailouts from EU and IMF, and adopted austerity measures, experiencing an economic recession. Ireland followed Greece, requiring a bailout in November 2010 and Portugal was next, in May 2011. In addition, Spain required official assistance in June 2012 along with Cyprus. The situation in most of these countries had improved due to fiscal reforms and domestic austerity measures. Though, recent Brexit movements created some instability in EU meaning that the road to full economic recovery seems to be long for now.

The latest financial crisis reveals many weaknesses of bank risk modelling. The respective versions of the Basel Accords offer evolving risk models that attempt to resolve the problems of arbitrary model choices by banks, portfolio invariance issues, and the various treatment of banking and trading books. A challenge that still lies ahead for regulators is compensating for the drawbacks of the applied measures. A substantial challenge of the financial crisis for risk modeling is also the revealed fallacy of composition in banking, which highlights the need for risk modeling from a systemic point of view in addition to an individual bank's perspective.

Systemic risk models allow regulators to account for spillovers and correlated exposure among banks that can destabilize the whole banking system during times of market distress. The evolving risk measures and models are gradually being included in the banking regulatory frameworks. The challenge of adapting the regulations to changing risk profiles of banks and banking systems lies still ahead.

3 Literature Review

For several years now, there has been a lot of research in what concerns the main mechanisms behind systemic risk. Some authors dedicated themselves to develop important theories about the causes of systemic risk and, thus, how to avoid the contagion effect.

Longstaff (22) reinforces the idea that there are at least three major channels by which contagion effects can be propagated through different financial markets. Those channels are correlated information channel, liquidity channel and risk-premium channel. The first one is related with the spread of news which apparently may seem irrelevant but can affect for example security prices in other markets or can be information about economic factors that also affects other markets. In addition, it can be to infer information from price changes in other markets. This channel impacts directly the prices, particularly if the market is more liquid than the market originally affected by the distress event. The second channel consists in a decrease of liquidity of all financial markets caused by a shock in a financial market. It is important to bear in mind that a distress event like this one may have a spiral effect meaning that it may be associated with a decline in credit availability and consequently with the increase of trading in other markets. The third channel is that a financial shock in one market may affect the willingness of market participants to bear risk in any market. Given this, prices can be affected as equilibrium risk premium adjust in return.

Additionally, Allen and Gale (2) developed a theory on contagion, arguing that different sectors of the banking system have overlapping claims on one another through interbank markets. Moreover, when one sector suffers a banking crisis, the other sectors are affected negatively because their claims on the troubled region fall in value. If this spillover effect is sufficiently strong, crisis can occur in the adjacent sectors. In extreme cases, the crisis passes from sector to sector resulting in a contagion.

De Bandt and Hartmann (7) also contributed to support the idea that we should look not only to the single banks` vulnerability but to the rapidly evolving financial institutions, which can be easily affected by contagion effect. It should be noticed that, in those times, way before the beginning of the financial crisis of 2007, the authors emphasize the relevance of explaining and preventing real crisis, highlighting the issue of bank contagion.

Benoit, Colliard, Hurlin and Pérignon (4) also referred the importance of information in the contagion effect. Indeed, if individuals believe that the failure of a bank is a signal that another bank can fail too, there is an informational link between these two banks and contagion can occur. Foucault (10) show that market illiquidity itself is contagious, so that a drop in liquidity for one asset can trigger a similar drop in other correlated assets, thus propagating problems.

Furthermore, Rochet and Tirole (29) suggested possible ways to prevent systemic risk in a financial system. They stated that the "Too big to fail" (TBTF) policy has an important role in doing so. It is characterized by protecting uninsured depositors from large insolvent banks, whose failure could affect the financial system as a whole. They also said that another way to avoid systemic risk consists in centralizing a bank`s liquidity management.

Hansen (13) distinguished systemic from systematic risk, stating that systematic risk has a universal recognized definition. Indeed, systematic risk can be denoted by market risk, meaning that it is the risk in the aggregate market that cannot be eliminated by diversification and that requires compensation. Contrarily, there is no consensus in what concerns systemic risk definition, although it is related with the risk of collapse of the entire financial system. Despite from that, this author also contributed, with his research, to find some of the greatest difficulties in measuring systemic risk. The main problem with systemic risk measurement is in quantifying systemic uncertainty. Uncertainty can be due to limited data, unknown models and misspecification of such models. Another important issue is that, as systemic risk does not have a single definition, there is no "perfect" model to measure it. Adding to this, it is of common sense that every model is limited as it simplifies and abstracts the information. For example, a model of financial networks is not an accurate measure of risk as it is difficult to make probabilistic assessments about more indirect linkages.

4 Empirical Descriptive Analysis

4.1 Data Description

The aim of this thesis is to identify and analyze the impact of systemic risk in Portugal, through an econometric model which allows to highlight the effect of a bank failure in the rest of the banking system and in other sectors, namely in the construction sector, in the electricity sector, in the telecommunications sector and in pulp and paper industry. The variables of most interest were selected to explain the dependent variable.

To get to the final sample were used EViews 10 program and excel. These tools helped in the sample construction and to perform sample statistics and estimates. In addition, they allowed to build some graphs and tables to achieve the defined objectives.

The graphs permitted to observe the evolution of the different variables and to understand how they relate.

Thus, we obtained the best model which defines the risk that other economic agents may incur given a bankruptcy of one financial institution.

4.1.1 Data Characterization

As mentioned in point 4.1, the main purpose of this study is taken through a descriptive analysis and from model adjustment. In this regard, it was performed an analysis of three models in order to evaluate the impact of BES bankruptcy in the structure of other banks operating in Portugal, and four models were analyzed to measure the impact of the banking sector imbalance in other economic sectors. The sample period starts in December 2000 and ends in October 2014, whereas the total of observations is 3280.

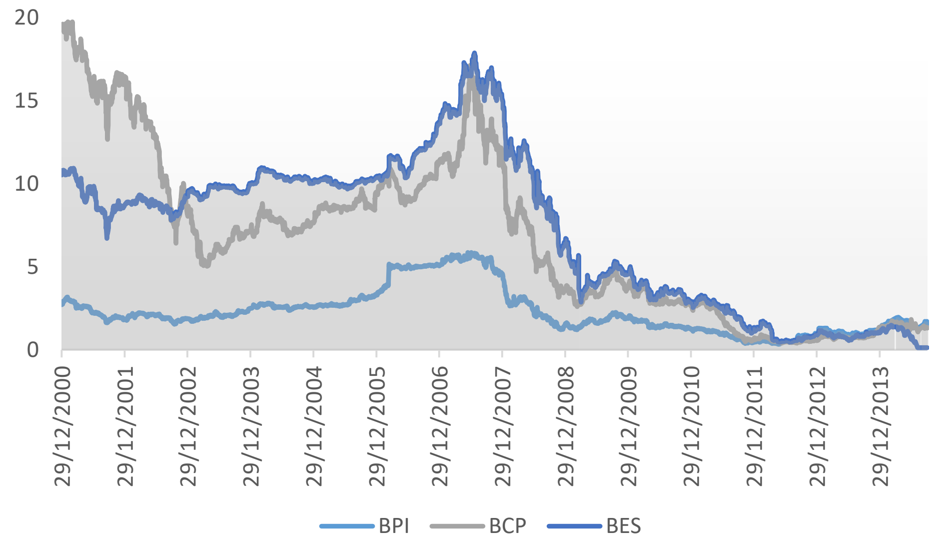
The analysis covered several economic and financial factors so that we attain the most realistic results possible.

The data used in the estimation of the econometric models was the following:

- Daily bank stock prices;

- Daily stock prices of four companies which were listed at the Top 5 ranking of Portuguese biggest companies in the construction sector, electricity sector, telecommunications sector and pulp and paper sector, respectively, in 2014 (the year the BES bankruptcy took place);
- Exchange Rate (EUR/USD);
- 6-month Euribor rates;
- Portuguese Gross Domestic Product.

Figure B.1: BPI, BCP and BES daily stock prices



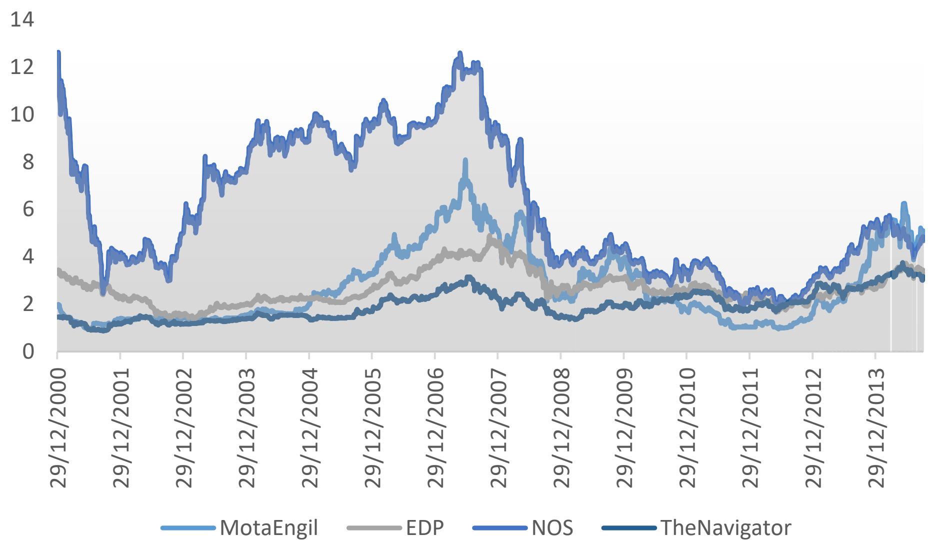
Souce: Investing.com & Bolsa PT

As we can observe in Figure B.1, BES stock prices had a positive trend until 2007, when they attained its maximum value. This was followed by a sharp decrease and in 2009/2010 there was a small recovery followed again by a drop until 2014, when it collapsed.

BPI stock prices evolution was similar to that seen in BES, although it presented better values in the crisis period when compared to BES. The highest value was observed in 2007, before the burst of the Subprime Crisis. Then, there was a significant decrease in BPI stock prices, which in 2010 recovered and kept an equilibrium until 2017.

The BCP stock prices decreased in 2002 and recovered right before 2007 when they declined sharply.

Figure B.2: Mota-Engil, EDP, NOS and The Navigator daily stock prices



Souce: Investing.com

According to Figure B.2, Mota-Engil stock prices had a positive trend until 2007 followed by a decrease still that year. There were two small recoveries, one in 2008 and one in 2009. After this second recovery, there was a decrease until 2011 and another price increase in 2012.

It was found that EDP stock prices declined slightly until 2002, with an increase until 2007. In the beginning of 2008, a decrease was observed and the stock prices remained stable over time.

NOS stock prices declined until 2001 and recovered until 2007, when they reduced significantly until 2012.

The Navigator stock prices had the lowest price variation when compared with the other companies´ stock prices. There was a slight increase until 2007, followed by a price reduction until 2008 and a price increase until 2011.

4.1.2 Variables Characterization

Most of the variables mentioned above have a daily periodicity, however the 6-month Euribor rate and the gross domestic product are defined on an annual basis. For this reason, it is crucial to explain the process through which the final daily data values were obtained. In this regard, the linear interpolation method was adopted. This method consists in using linear polynomials[1] to construct new data points within the range of a discrete set of known data points.

In addition to these variables, a dummy variable was included in order to complement the model. The dummy variable is represented with 0 for all dates before "Banco Espírito Santo" bankruptcy and is represented with 1 for all dates after this date.

4.2 Models

The key variables in this analysis are daily stock prices of three of the biggest banks operating in Portugal and daily stock prices of four companies which were listed at the Top 5 ranking of Portuguese biggest companies in the construction sector, electricity sector, telecommunications sector and pulp and paper sector, respectively, in the year the BES bankruptcy took place, corresponding to the dependent variables. Given this, were gathered the variables which are included in the table B.1, Appendix B.

Firstly, we considered to use multiple linear regression models. Given that, a logarithmic transformation of some variables, including both dependent and independent variables, was introduced in order to make the data more interpretable. The logarithmic transformation has also been used to help to meet the assumptions of inferential statistics. The logarithm function tends to squeeze together the larger values in the data set and stretches out the smaller values. This is useful in this analysis as the stock prices of "Banco Espírito Santo" immediately after the banks` bankruptcy had an almost residual value. Applying the logarithmic function to the daily stock prices of "Banco Espírito Santo", allowed to increase the statistical significance of other variables to conform to the model.

Note that, for BPI we did not apply a logarithmic transformation because it did not add information to the model (R squared was smaller and independent variables with a lower level of statistical significance).

Consequently, it was assumed that the stock prices models may be described by the following equations:

[1] In table E.1 there is an example of this process.

$$\log(BES_t) = \alpha + \beta_1 \log(BPI_t) + \beta_2 \log(BCP_t) + \beta_3 \log(Exchange\ rate_t) + \beta_4 \log(6\ months\ Euribor_t) + \beta_5 \log(GDP_t) + DUMMY_t + \varepsilon_t \quad (1)$$

$$\log(BCP_t) = \alpha + \beta_1 \log(BES_t) + \beta_2 \log(BPI_t) + \beta_3 \log(Exchange\ rate_t) + \beta_4 \log(6\ months\ Euribor_t) + \beta_5 \log(GDP_t) + DUMMY_t + \varepsilon_t \quad (2)$$

$$BPI_t = \alpha + \beta_1 BESt + \beta_2 BCPt + \beta_3\ Exchange\ rate_t + \beta_4\ 6\ months\ Euribor_t + \beta_5\ GDP_t + DUMMY_t + \varepsilon_t \quad (3)$$

Where BES, BCP and BPI correspond to the dependent variable, exchange rate corresponds to the EUR/USD exchange rate, GDP correspond to the portuguese gross domestic product and the residual variable is ε_t.

In order to use a multiple linear regression model we need to guarantee homoscedasticity, through White-test, for example, and residuals autocorrelation absence, through Durbin-Watson test.

The assumption of homoscedasticity is crucial to linear regression models and corresponds to equal levels of random disturbance between quantitative dependent variables across a range of independent variables.

The Durbin-Watson Test is a measure of autocorrelation or serial correlation in residuals from a statistical regression analysis and reports a test statistic, with a value between 0 and 4, where 2 is no autocorrelation, from 0 to 2 is positive autocorrelation and from 2 to 4 is negative autocorrelation.

For instance, considering that the stock prices tend not to change significantly from one day to another, the prices from one day to the next day can be potentially highly correlated.

Though, when analyzing the model, the homoscedasticity problem raised and we found out that the residuals were autocorrelated (Durbin-Watson test = 0.269), consequently, we concluded that the hypothesis of a multiple linear regression model estimated by the Ordinary Least Squares Method does not verify, therefore it is not possible to take feasible conclusions from this model estimation.

For this reason, a more accurate alternative is to estimate Autoregressive Distributed Lag (ADL) models, because they take into consideration the application of lags to both dependent and independent variables which allows to measure the changes in the dependent variable based on current and lagged values of the explanatory variables. We will consider one to three lags in order to maintain the parsimonious principle.

The parsimonious principle consists in using the simplest model possible with the least assumptions and variables but with greatest explanatory power to filter unnecessary aspects but without sacrificing comprehensiveness.

4.3 Autoregressive Distributed Lag

The autoregressive distributed lag model is applied for time series data in which a regression equation is used to predict current values of a dependent variable based on both the current values of an explanatory variable and the lagged (past period) values of that explanatory variable (Hassler and Wolters 2005).

In time series models, in contrast to cross-sectional models, we must consider not only how much effect *x* has on *y*, but when the effect is felt. Therefore, the need to consider distributed lags arise when any economic cause produces its effects only after some lag in time, meaning that it´s effect is not felt at once at a single point in time but it is distributed over a period of time.

The autoregressive distributed lag model is generally given by:

$$y_t = \beta_0 x_t + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \cdots + \beta_k x_{t-k} + \varepsilon_t \quad (4)$$

in which, for one-off unit change in x there is an impact on y, this impact is captured by β_0. Then β_1 is the impact on y after one period, β_2 is the impact on y after two periods, and β_k is the impact on y after k periods.

If all the coefficients are collected: $\{\beta_0, \beta_1, \beta_2, ..., \beta_k\}$, they are called impulse response function of the mapping on x_t to y_t. The above model is the lagged model accounting for the changes in $\{\beta_0, \beta_1, \beta_2, ..., \beta_k\}$ on x for lagged period t. On the *y*-axis, the *y*-dependent may response to exogeneous factors as well, thus, the ADL may accommodate for both x and y as:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + ... + \alpha_p y_{t-p} + \beta_0 x_t + \beta_1 x_{t-1} + ... + \beta_k x_{t-k} + \varepsilon_t \quad (5)$$

The first order dynamic linear regressive model or ADL(1,1) may be used for short-run analysis and it is given by:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t \qquad \text{where } t = 1, 2, \dots, \mathrm{T} \quad (6)$$

In this short-run analysis, y_t is stable and would converge to equilibrium with the condition: -1 < α_1 <1.

Thus, assuming that y_t is stationary, that is, there is an equal effect of current x_t on future y_{t+1} and of past x_{t-1} on y_t, and the autoregressive polynomial is invertible, meaning that it cannot be a zero polynomial, and considering $E(\varepsilon_t|x_t) = 0$ (excluding any impacts from y_t in x_t) we will determine the following dynamic inter-relations:

$$\frac{\partial y_t}{\partial x_t}, \frac{\partial y_{t+1}}{\partial x_t}, \frac{\partial y_{t+2}}{\partial x_t}$$

For the equations:

$$y_t = \alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t \quad (7)$$

$$y_{t+1} = \alpha_0 + \alpha_1 y_t + \beta_0 x_{t+1} + \beta_1 x_t + \varepsilon_{t+1} \quad (8)$$

$$y_{t+2} = \alpha_0 + \alpha_1 y_{t+1} + \beta_0 x_{t+2} + \beta_1 x_{t+1} + \varepsilon_{t+2} \quad (9)$$

The dynamic multipliers can be given by:

- $\frac{\partial y_t}{\partial x_t} = \beta_0$ (impact effect of *x* on *y*) (10)

- $\frac{\partial y_{t+1}}{\partial x_t} = \frac{\partial y_t}{\partial x_{t-1}} = \alpha_1 \cdot \beta_0 + \beta_1$

(dynamic marginal effect of *x* on *y* at one lag), considering that:

$$y_{t+1} = \alpha_0 + \alpha_1 (\alpha_0 + \alpha_1 y_{t-1} + \beta_0 x_t + \beta_1 x_{t-1} + \varepsilon_t) + \beta_0 x_{t+1} + \beta_1 x_t + \varepsilon_{t+1} . \quad (11)$$

- $\frac{\partial y_{t+2}}{\partial x_t} = \frac{\partial y_t}{\partial x_{t-2}} = \alpha_1 \frac{\partial y_{t+1}}{\partial x_t} = \alpha_1 (\alpha_1 \cdot \beta_0 + \beta_1)$

(dynamic marginal effect of *x* on *y* at two lags)

Generalizing:

- $\frac{\partial y_{t+k}}{\partial x_t} = \frac{\partial y_t}{\partial x_{t-k}} = \alpha_1 \frac{\partial y_{t+1}}{\partial x_t} = \alpha_1{}^{\mathrm{k}-1} (\alpha_1 \cdot \beta_0 + \beta_1)$

Therefore, due to stationarity $|\alpha_1| < 1$, shocks have transitory effects:

$$\frac{\partial y_{t+k}}{\partial x_t} \rightarrow 0 \text{ as } k \rightarrow \infty$$

For instance, if autocorrelation between y_t and x_t is strong, then a transitory effect will influence significantly the future periods, so it should not be considered in long-run analysis, but to account for short-run effects.

To assess the ADL regression model, the stationarity of the dependent variable will be evaluated through a Dickey-Fuller test. If the dependent variable presents a unit root, then that variable can be modelled with first differences - lag(1).

Unit root tests are tests for stationarity in a time series. A time series, in turn, has stationarity if a shift in time does not cause a change in the distribution´s shape.

This assessment was made to the seven independent variables, BES, BPI, BCP, Mota-Engil, EDP, NOS and The Navigator and all these variables have a unit root[2].

[2] As we can observe in tables C.1-C.7.

Taking all into an account the stock prices models may be described by the following equations based in ADL models:

$$BES_t = \alpha + \beta_1 BES_{t-1} + \beta_2 BCP_t + \beta_3 BCP_{t-1} + \beta_4 BPI_t + \beta_5 BPI_{t-1} + \beta_6 Exchange\ rate_t + \beta_7 Exchange\ rate_{t-1} + \beta_8 Euribor_t + \beta_9 GDP_t + \varepsilon_t \tag{12}$$

$$BCP_t = \alpha + \beta_1 BCP_{t-1} + \beta_2 BPI_t + \beta_3 BPI_{t-1} + \beta_4 BES_t + \beta_5 BES_{t-1} + \beta_6 Exchange\ rate_t + \beta_7 Exchange\ rate_{t-1} + \beta_8 Euribor_t + \beta_9 GDP_t + \varepsilon_t \tag{13}$$

$$BPI_t = \alpha + \beta_1 BPI_{t-1} + \beta_2 BES_t + \beta_3 BES_{t-1} + \beta_4 BCP_t + \beta_5 BCP_{t-1} + \beta_6 Exchange\ rate_t + \beta_7 Exchange\ rate_{t-1} + \beta_8 Euribor_t + \beta_9 GDP_t + \beta_{10} DUMMY_t + \beta_{11} DUMMY_{t-1} + \varepsilon_t \tag{14}$$

$$MotaEngil_t = \alpha + \beta_1 MotaEngil_{t-1} + \beta_2 BES_t + \beta_3 BES_{t-1} + \beta_4 BCP_t + \beta_5 BCP_{t-1} + \beta_6 BPI_t + \beta_7 BPI_{t-1} + \beta_8 DUMMY_t + \beta_9 DUMMY_{t-1} + \varepsilon_t \tag{15}$$

$$EDP_t = \alpha + \beta_1 EDP_{t-1} + \beta_2 BES_t + \beta_3 BES_{t-1} + \beta_4 BCP_t + \beta_5 BCP_{t-1} + \beta_6 BPI_t + \beta_7 BPI_{t-1} + \beta_8 DUMMY_t + \beta_9 DUMMY_{t-1} + \varepsilon_t \tag{16}$$

$$NOS_t = \alpha + \beta_1 NOS_{t-1} + \beta_2 BES_t + \beta_3 BES_{t-1} + \beta_4 BCP_t + \beta_5 BCP_{t-1} + \beta_6 BPI_t + \beta_7 BPI_{t-1} + \beta_8 DUMMY_t + \beta_9 DUMMY_{t-1} + \varepsilon_t \tag{17}$$

$$TheNavigator_t = \alpha + \beta_1 TheNavigator_{t-1} + \beta_2 BES_t + \beta_3 BES_{t-1} + \beta_4 BCP_t + \beta_5 BCP_{t-1} + \beta_6 BPI_t + \beta_7 BPI_{t-1} + \beta_8 DUMMY_t + \beta_9 DUMMY_{t-1} + \varepsilon_t \tag{18}$$

4.4 Model Analysis

Building a model involves science, statistical methods and common sense, with the aim of finding the model which best explains the dependent variable. All the estimated models which are going to be analyzed at this point were performed with the help of EViews 10.

It is important to mention that multiple simulations with multiple lags have been made but these are the models that best explain the dependent variables.

When considering the seven ADL regression models, equations 7 to 13 we have checked that not all the variables are statistically significant. And, it is important to stress that the statistic tests were performed with a significance level of 0.05.

The correlation between each of the companies´ stock prices and the banks´ stock prices vary (Tables A.3.1 and A.3.2). However, there is a strong correlation between the companies´ stock prices and BPI stock prices. This was because even after BES bankruptcy, BES stock prices were presented as being constant and BPI stock prices decreased as what we observe for the other institutions. Despite that, for NOS stock prices, the correlations with BES and BPI stock prices are very similar, 0.863 and 0.877, respectively. In what refers to the The Navigator stock prices we realized that there was a negative correlation with BES and BCP. This is verified because The Navigator stock prices did not change substantially over time.

Table A.3.1: Correlations Matrix

	BES	BPI	BCP	Exchange Rate	Euribor	GDP	DUMMY
BES	1						
BPI	0.8679	1					
BCP	0.7989	0.6604	1				
Exchange Rate	0.6443	0.4189	0.5792	1			
Euribor	0.6906	0.4564	0.7429	0.6835	1		
GDP	-0.4855	-0.2235	-0.7290	-0.5286	-0.4217	1	
DUMMY	-0.1254	-0.0432	-0.0874	-0.0658	-0.1259	0.04484	1

Souce: PORDATA, Investing.com & Bolsa PT

Table A.3.2: Correlations Matrix

	BES	BPI	BCP	Mota-Engil	EDP	NOS	The Navigator
BES	1						
BPI	0.868	1					
BCP	0.799	0.660	1				
Mota-Engil	0.445	0.717	0.181	1			
EDP	0.402	0.623	0.295	0.848	1		
NOS	0.863	0.877	0.616	0.550	0.448	1	
The Navigator	-0.184	0.206	-0.342	0.681	0.612	0.064	1

Souce: PORDATA, Investing.com & Bolsa PT

One way of assessing the quality of the model adjustment is through the determination coefficient R^2. This statistical measure determines the variability value of the dependent variable which is explained by the adjusted regression model, in other words it is a statistical measure of how close the data are to the fitted regression line. Thus, if the R^2 of a model is 0.50 it means that approximately half of the observed variation can be explained by the model´s inputs.

Table D.1: Results of the estimation of BES model

Model 1 - BES

Variables	Estimates	Standard deviation	P-Value
BES_{t-1}	0.994	0.001	0.000
BCP	0.044	0.014	0.002
BCP_{t-1}	-0.045	0.014	0.002
BPI	0.217	0.047	0.000
BPI_{t-1}	-0.197	0.047	0.000
ExchangeRate	-1.486	0.175	0.000
$ExchangeRate_{t-1}$	1.469	0.174	0.000
Euribor	0.003	0.003	0.336
GDP	-9.45e-07	2.70e-07	0.0005
Constant	0.173	0.059	0.0033
R^2	0.9993		
Prob (F-statistic)	0.0000		

Table D.2: Results of the estimation of BCP model

Model 2 - BCP

Variables	Estimates	Standard deviation	P-Value
$\mathbf{BCP}_{t-1}$	0.994	0.002	0.000
BES	0.064	0.021	0.002
$\mathbf{BES}_{t-1}$	-0.066	0.021	0.002
BPI	0.954	0.054	0.000
$\mathbf{BPI}_{t-1}$	-0.937	0.055	0.000
ExchangeRate	-1.114	0.213	0.000
$\mathbf{ExchangeRate}_{t-1}$	1.093	0.213	0.000
Euribor	0.008	0.004	0.068
GDP	-9.38e-07	3.27e-07	0.004
Constant	0.178	0.072	0.013
$\mathbf{R^2}$ **Prob (F-statistic)**	0.9992 0.0000		

Table D.3: Results of the estimation of BPI model

Model 3 – BPI

Variables	Estimates	Standard deviation	P-Value
$\mathbf{BPI}_{t-1}$	0.999	0.002	0.000
BES	0.029	0.006	0.000
$\mathbf{BES}_{t-1}$	-0.029	0.006	0.000
BCP	0.089	0.005	0.000
$\mathbf{BCP}_{t-1}$	-0.089	0.005	0.000
ExchangeRate	-1.196	0.066	0.003
$\mathbf{ExchangeRate}_{t-1}$	0.206	0.065	0.002
Euribor	-0.002	0.001	0.053
DUMMY	-0.234	0.043	0.000
$\mathbf{DUMMY}_{t-1}$	0.247	0.045	0.000
GDP	-3.29e-08	1.01e-07	0.744
Constant	-0.004	0.022	0.842
$\mathbf{R^2}$ **Prob (F-statistic)**	0.9990 0.0000		

Table D.4: Results of the estimation of Mota-Engil model

Model 4 – Mota-Engil

Variables	Estimates	Standard deviation	P-Value
$\mathbf{Mota-Engil}_{t-1}$	0.997	0.001	0.000
BES	0.054	0.010	0.000
$\mathbf{BES}_{t-1}$	-0.055	0.010	0.000
BCP	0.085	0.008	0.000
$\mathbf{BCP}_{t-1}$	-0.085	0.008	0.000
BPI	0.328	0.028	0.000
$\mathbf{BPI}_{t-1}$	-0.321	0.028	0.000
DUMMY	-1.021	0.069	0.000
$\mathbf{DUMMY}_{t-1}$	1.058	0.071	0.000
Constant	0.006	0.003	0.0335
R^2 Prob (F-statistic)	0.9981 0.0000		

Table D.5: Results of the estimation of EDP model

Model 5 – EDP

Variables	Estimates	Standard deviation	P-Value
$\mathbf{EDP}_{t-1}$	0.996	0.001	0.000
BES	0.015	0.006	0.015
$\mathbf{BES}_{t-1}$	-0.016	0.006	0.011
BCP	0.056	0.005	0.000
$\mathbf{BCP}_{t-1}$	-0.056	0.005	0.000
BPI	0.208	0.017	0.000
$\mathbf{BPI}_{t-1}$	-0.204	0.017	0.000
DUMMY	-0.389	0.042	0.000
$\mathbf{DUMMY}_{t-1}$	0.393	0.043	0.000
Constant	0.007	0.003	0.023
R^2 Prob (F-statistic)	0.9966 0.0000		

Table D.6: Results of the estimation of NOS model

Model 6 – NOS

Variables	Estimates	Standard deviation	P-Value
$\mathbf{NOS_{t-1}}$	0.994	0.002	0.000
BES	0.071	0.016	0.000
$\mathbf{BES_{t-1}}$	-0.067	0.016	0.000
BCP	0.106	0.013	0.000
$\mathbf{BCP_{t-1}}$	-0.108	0.013	0.000
BPI	0.505	0.044	0.000
$\mathbf{BPI_{t-1}}$	-0.499	0.044	0.000
DUMMY	-0.301	0.109	0.006
$\mathbf{DUMMY_{t-1}}$	0.344	0.112	0.002
Constant	0.013	0.005	0.005
R^2	0.9986		
Prob (F-statistic)	0.0000		

Table D.7: Results of the estimation of The Navigator model

Model 7 – The Navigator

Variables	Estimates	Standard deviation	P-Value
$\mathbf{TheNavigator_{t-1}}$	0.996	0.002	0.000
BES	0.012	0.004	0.010
$\mathbf{BES_{t-1}}$	-0.013	0.004	0.005
BCP	0.039	0.004	0.000
$\mathbf{BCP_{t-1}}$	-0.039	0.004	0.000
BPI	0.150	0.012	0.000
$\mathbf{BPI_{t-1}}$	-0.147	0.012	0.000
DUMMY	-0.117	0.030	0.000
$\mathbf{DUMMY_{t-1}}$	0.106	0.031	0.001
Constant	0.009	0.003	0.004
R^2	0.9972		
Prob (F-statistic)	0.0000		

The model 1 corresponds to the best performance, that is, 99.93% of the dependent variable is explained by the model regressors, although the three first models, for BES (Table D.1), BCP (Table D.2) and BPI (Table D.3) have very similar determination coefficients. Concerning the final four models, Mota-Engil (Table D.4), EDP (Table D.5) and NOS (Table D.6) the best performance is for 99.86% from NOS model.

As mentioned above, Table D.1 presents the results of the model estimates which intends to explain the evolution of BES stock prices. The results of Wald`s test indicate that only the 6-month euribor rates are not statistically significant for the first model, meaning that all the other dependent variables revealed explanatory power about BES stock prices behavior.

Financially, BES_{t-1}, BCP_t, BPI_t, $Euribor_t$ and $Exchange\ rate_{t-1}$ positively affect the dependent variable (BES stock price). Contrarily, BCP_{t-1}, BPI_{t-1}, $Exchange\ rate_t$ and GDP_t negatively influence BES stock price at period t.

For the BCP stock price model, represented in the table D.2, the results of Wald`s test suggest that also only 6-month Euribor rates are not statistically significant for this second model, meaning that all the other dependent variables revealed explanatory power about the progress of BCP stock prices.

Financially, BCP_{t-1}, BES_t, BPI_t, $Exchange\ rate_{t-1}$, $Euribor_t$ affect positively the dependent variable (BCP stock prices). However, BES_{t-1}, BPI_{t-1}, $Exchange\ rate_t$ and GDP_t affect negatively BCP stock prices.

As represented in table D.3, for BPI stock prices model the results of Wald`s test stress that only the 6-month Euribor rates and GDP are not statistically significant, meaning all the remaining variables have explanatory power about the progress of BPI stock prices.

Financially, BPI_{t-1}, BES_t, BCP_t, $Exchange\ rate_{t-1}$ and $DUMMY_{t-1}$ positively affect the dependent variable (BPI stock price). Contrarily, BES_{t-1}, BCP_{t-1}, $Exchange\ rate_t$, $Euribor_t$, $DUMMY_t$ and GDP_t negatively influence BES stock price at period t.

In what concerns the dummy variable, as it was mentioned before, it assumes the value 1 after the BES bankruptcy, being its coefficient $\beta_{10} = -0.234$ (Table D.3) , it influences negatively BPI stock prices, *ceteris paribus*. This means that, it increases systemic risk by 0.234 units.

We have also seen that if we add the same dummy variable in BCP stock prices model the $DUMMY_t$ is not statistically significant, meaning that the bankruptcy of "Banco Espírito Santo" did not affect BCP stock prices in such a significant way as it affected BPI stock prices.

Tables D.4, D.5, D.6 and D.7 present the results of the model estimates which intends to explain the evolution of stock prices for non-financial institutions. The results of Wald`s test for the four models indicate that all the independent variables, I mean, banks´ stock prices revealed explanatory power about the behavior of the dependent variables.

Financially, for these four models (Tables D.4, D.5, D.6 and D.7), BES_t, BCP_t, BPI_t, and $DUMMY_{t-1}$ positively affect the dependent variable at period t. Contrarily, BES_{t-1}, BCP_{t-1}, BPI_{t-1} and $DUMMY_t$ negatively influence the dependent variable at period t.

In addition, the dummy variable for Mota-Engil model has a coefficient $\beta_8 = -1.021$, meaning that BES collapse influenced negatively Mota-Engil stock prices, increasing systemic risk by 1.021 units. In EDP and NOS models the systemic risk increase is similar, 0.389 and 0.301, respectively. Finally, in what concerns The Navigator model the systemic risk increase was 0.117.

This analysis came up with a result we still have no answer for, which is the fact that banks` or non-financial institutions stock prices time lag impacts negatively on another not lagged banks` or non-financial institutions stock prices.

5 Conclusions

Taking into account the undergoing financial situation in Portugal and in many other economies resulting from the recent financial crisis which began in 2007, and considering the dimension of the negative effects which have surfaced during the recent years, I thought it was necessary to find a proxy to evaluate the real impact of systemic risk in the financial system and in the Portuguese economy. Therefore the main aim of this work was to identify the effects of a financial institution`s bankruptcy in other institutions operating in the domestic market.

The seven models adopted to assess this issue allowed to take important conclusions about the relationship between the stock prices of three banks and the stock prices of four non-financial institutions considered in this study.

In fact, when we tried to assess the horizontally systemic risk[3], there is a positive relationship between BES stock prices and BPI and BCP stock prices when comparing the same time period. That is to say that the behavior of BCP and BPI stock prices is similar to that behavior of BES stock prices. Moreover, the introduction of a dummy variable in such a way that we could distinguish the period before BES bankruptcy and the period after BES bankruptcy enabled us to quantify systemic risk in the case of BPI stock prices supporting the above statement.

In respect to the impact of BES bankruptcy in non-financial institutions, that is, considering vertically systemic risk, and according to the dummy variable, Mota-Engil was the most affected company. This could have arisen for two main reasons. The first one is that, as we mentioned previously in the section "2.2. Portugal and the Crisis", the real estate market was largely affected by the instability in the banking sector, and as consequence it also impacted the construction sector. On the other hand, construction companies largely depend on financing and on public and private entities investment what can justify a negative effect on Mota-Engil stock prices.

If we consider the contagion effect[4] as a mechanism of systemic risk, we can conclude that NOS stock prices were the most affected by this phenomenon, as they are

[3] As mentioned in section "1.1 Systemic Risk", the horizontal approach is limited to events in the financial system.
[4] The higher or lower interconnection between those institutions will determine the transmission of shocks through different channels that will cause the contagion effect.

highly correlated with BPI and BES stock prices, meaning that they are interconnected. So, we can say that a crisis of confidence may lead to uncertainty in the real economy and not only in the financial institutions.

The economic adjustment program in Portugal brought serious repercussions in the short term, exacerbating the effects of the recession in the real economy. However, it is important to underline the beneficial results of the economic adjustment program in the long term. It was due to the economic adjustment program that a public finances recovery took place, the financial sector stabilised and it brought the economy back on a path of recovery. Adding to this, it allowed for a substantial improvement in the nominal and structural government deficit. And important steps have also been taken in the banking sector, namely the reinforcement in capitalization of the banks and improvements in banking supervision.

Nonetheless, this study allows us to conclude that the bankruptcy of a bank can impact negatively other institutions in the same domestic market, because they are positively correlated. A distress event in one financial institution can create instability in other financial and non-financial institutions.

We should bear in mind the existence of the economic cycles and the interconnection of the economies in different countries and as Lourtie (23) notes, "One of the lessons from the…crisis is that Portugal's fate is not dependent on its decisions alone".

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Appendix

A. Description and Descriptive Statistics

A.1. Variables description

Table A.1: Variables Description

Variable Code	Description
BES	Share price of BES bank on a daily basis
BPI	Share price of BPI bank on a daily basis
BCP	Share price of BCP bank on a daily basis
Mota-Engil	Share price of Mota-Engil company on a daily basis
EDP	Share price of EDP company on a daily basis
NOS	Share price of NOS company on a daily basis
The Navigator	Share price of The Navigator company on a daily basis
Exchange Rate	EUR/USD
Euribor	Euro Interbank Offer Rate based on 6 months interest rates on an annual basis
GDP	Portuguese Gross Domestic Product on an annual basis

A.2. Variables Descriptive Statistics

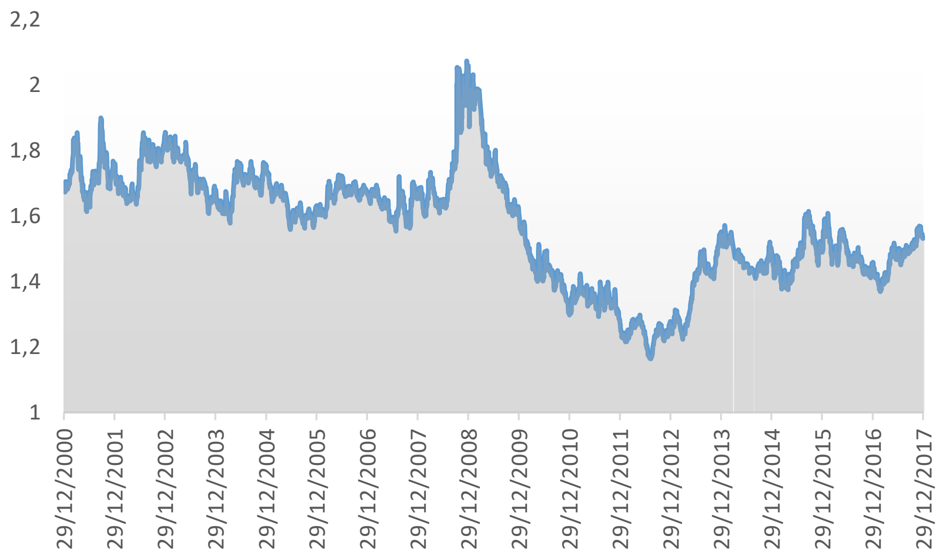
Table A.2: Variables descriptive statistics

Variables	Observations	Average	Standard Deviation	Minimum	Maximum
BES	3281	7.519	4.503	0.12	17.87
BPI	3281	2.343	1.373	0.339	5.854
BCP	3281	6.957	4.928	0.398	19.738
Mota-Engil	3281	2.686	1.572	0.940	8.100
EDP	3281	2.665	0.712	1.325	4.910
NOS	3281	6.140	2.903	1.779	12.633
The Navigator	3281	1.895	0.568	0.870	3.762
Exchange Rate	3281	1.596	0.183	1.164	2.074
Euribor	3281	2.569	1.321	0.32	4.83
GDP	3281	1600364.7	16860.16	128466.3	179929.8

Souce: PORDATA, Investing.com & Bolsa PT

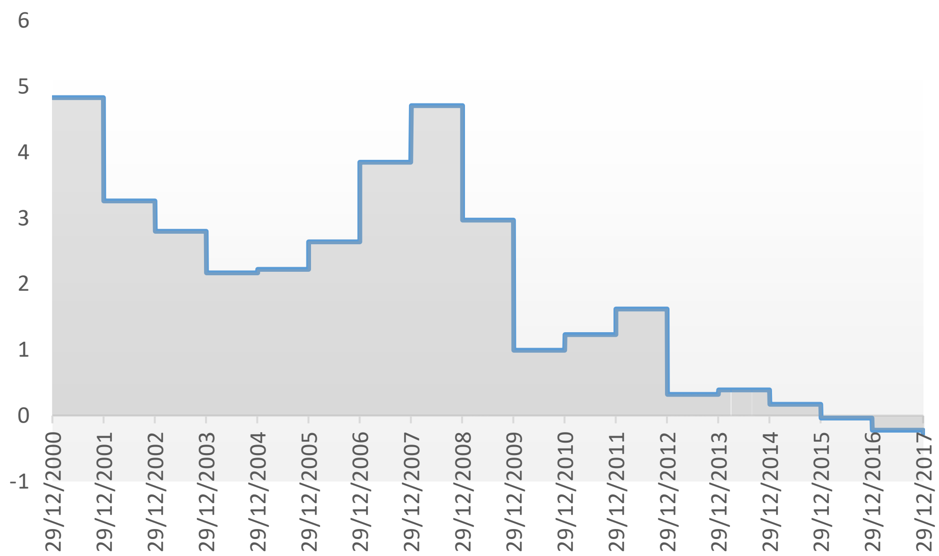
B. Descriptive Figures

Figure B.3: Exchange Rate



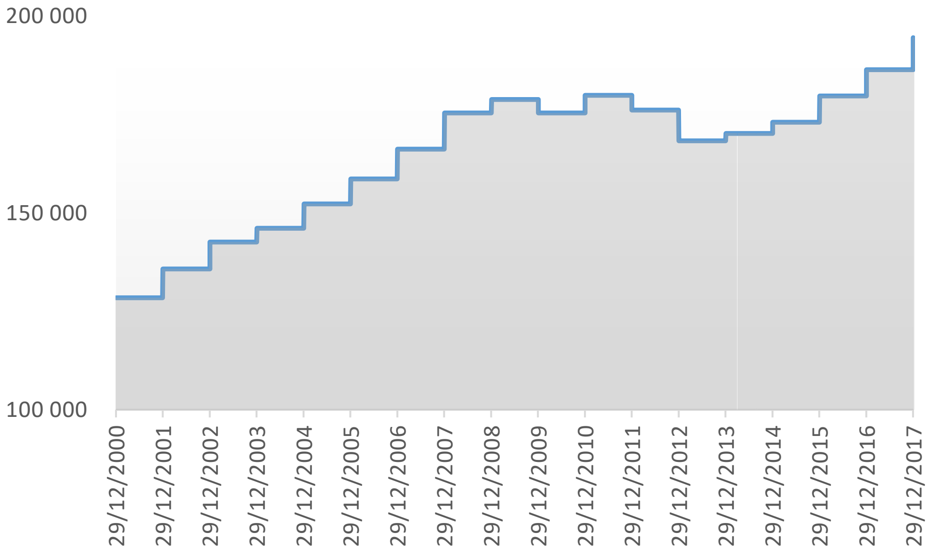
Souce: PORDATA

Figure B.4: 6-month Euribor rates



Souce: PORDATA

Figure B.5: Portuguese gross domestic product



Souce: PORDATA

C. Test for unit root

Table C.1: Augmented Dickey-Fuller test for unit root for BPI

BPI lag(3) - Augmented Dickey-Fuller test for unit root

Critical Values	t-Statistic	Prob
1% Level	-2.566	
5% Level	-1.941	
10% Level	-1.617	
ADF test statistic – BPI	-29.637	0.0000

Table C.2: Augmented Dickey-Fuller test for unit root for BES

BES lag(3) - Augmented Dickey-Fuller test for unit root

Critical Values	t-Statistic	Prob
1% Level	-2.566	
5% Level	-1.941	
10% Level	-1.617	
ADF test statistic	-27.451	0.0000

Table C.3: Augmented Dickey-Fuller test for unit root for BCP

BCP lag(3) - Augmented Dickey-Fuller test for unit root

Critical Values	t-Statistic	Prob
1% Level	-2.566	
5% Level	-1.941	
10% Level	-1.617	
ADF test statistic	-27.548	0.0000

Table C.4: Augmented Dickey-Fuller test for unit root for Mota-Engil

Mota-Engil lag(3) - Augmented Dickey-Fuller test for unit root

Critical Values	t-Statistic	Prob
1% Level	-2.566	
5% Level	-1.941	
10% Level	-1.617	
ADF test statistic	-28.503	0.0000

Table C.5: Augmented Dickey-Fuller test for unit root for EDP

EDP lag(3) - Augmented Dickey-Fuller test for unit root

Critical Values	t-Statistic	Prob
1% Level	-2.566	
5% Level	-1.941	
10% Level	-1.617	
ADF test statistic	-29.713	0.0000

Table C.6: Augmented Dickey-Fuller test for unit root for NOS

NOS lag(3) - Augmented Dickey-Fuller test for unit root

Critical Values	t-Statistic	Prob
1% Level	-2.566	
5% Level	-1.941	
10% Level	-1.617	
ADF test statistic	-26.988	0.0000

Table C.7: Augmented Dickey-Fuller test for unit root for The Navigator

The Navigator lag(3) - Augmented Dickey-Fuller test for unit root

Critical Values	t-Statistic	Prob
1% Level	-2.566	
5% Level	-1.941	
10% Level	-1.617	
ADF test statistic	-29.376	0.0000